# CERTIFICATE OF TRANSLATION

I, TAKESHI OSHIO, a Patent Attorney, of Fifteenth Floor, Crystal Tower, 1-2-27 Shiromi, Chuo-ku, Osaka 540-6015, Japan HEREBY CERTIFY that I am acquainted with the English and Japanese languages and that I have read the attached English translation and found it to be a true and accurate translation of Japanese Patent Application No. 6-217150 filed on 12 September, 1994 in the name of MATSUSHITA ELECTRIC INDUSTRIAL CO., LTD.

Dated this 14th day of November, 2002.

Takeshi Oshio

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| [Title of the Invention] | LAMINATION CERAMIC CHIP INDUCTOR AND METHOD FOR PRODUCING THE SAME |
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[Name of the Document] SPECIFICATION

[Title of the Invention] Lamination Ceramic Chip Inductor and Method for Producing the Same

[Claims]

[Claim 1] A lamination ceramic chip inductor, comprising a coil-shaped conductive line obtained by laminating a plurality of magnetic bodies or insulation layers with a plurality of conductive layers alternately, and then electrically connecting each of the conductive layers, wherein at least one of the conductive layers is a plated conductive layer formed to have pattern as a result of electroforming.

[Claim 2] A lamination ceramic chip inductor according to claim 1, wherein at least one of the conductors connected to the plated conductive layer is a thick film conductor formed by printing.

[Claim 3] A lamination ceramic chip inductor, comprising a coil-shaped conductive line obtained by laminating a plurality of magnetic bodies or insulation layers with a plurality of conductive layers alternately, and then electrically connecting each of the conductive layers; wherein the conductive layer having a shape of a straight line or a shape of a wave is interposed between the magnetic bodies or the insulating layers, and that such conductive layers are plated conductive layers formed to have pattern as a result of electroforming.

[Claim 4] A method for producing a lamination

ceramic chip inductor, comprising the steps of: forming a plated conductive pattern on a conductive base plate by electroforming; transferring the plated conductive pattern onto a magnetic sheet or onto an insulation layer; forming a lamination body by laminating a plurality of magnetic sheets or a plurality of insulation layers having the plated conductive pattern transferred thereon while electrically connecting the conductive patterns on the adjacent magnetic sheets or on the adjacent insulating layers to each other; and sintering the lamination body.

[Claim 5] A method for producing a lamination ceramic chip inductor, comprising the steps of: forming a plated conductive pattern on a conductive base plate by electroforming; forming a first sheet by transferring the plated conductive pattern on a magnetic sheet or on an insulation layer; forming a second sheet by printing a thick film conductive pattern on the magnetic sheet or on the insulation layer; forming a lamination body by laminating a plurality of first sheets and a plurality of second sheets alternately while electrically connecting the plated conductive patterns on the first sheets and the thick film conductive patterns on the adjacent second sheets to each other; and sintering the lamination body.

[Claim 6] A method for producing a lamination ceramic chip inductor, comprising the steps of: forming a plated conductive pattern on a conductive base plate by electroforming; forming first sheets by transferring the plated conductive pattern on magnetic sheets or on insulation layers; forming second sheets by printing and applying a thick film conductor on through-holes and the vicinity thereof formed in the magnetic sheets or the insulation

layers; forming a lamination body by laminating the first sheets and the second sheets alternately in the manner that the second sheet is interposed between two of the first sheets while electrically connecting the plated conductive patterns on the first sheets and the thick film conductive patterns on the adjacent second sheet; and sintering the lamination body.

[Claim 7] A method for producing a lamination ceramic chip inductor according to any one of claims 4, 5 and 6, further comprising the steps of: printing a magnetic body or an insulator on the electroformed plated conductive pattern formed on the conductive base plate and drying; adhering a thermally releasable foam sheet on the magnetic body or on the insulator by heating and foaming; forming a plated conductive greensheet by peeling off the base plate from the plated conductive pattern, the magnetic sheet or the insulator, and the foam sheet; and forming the lamination body using the plated conductive greensheet.

[Claim 8] A method for producing a lamination ceramic chip inductor according to any one of claims 4, 5 and 6, further comprising the steps of: adhering the thermally releasable foam sheet to the plated conductive pattern electroformed on the conductive base plate by heating and foaming; transferring a magnetic sheet or an insulator onto the plated conductive pattern after peeling off the base plate from the plated conductive pattern and the foam sheet; forming a plated conductive greensheet by peeling off the foam sheet from the plated conductive pattern; and forming the lamination body using the plated conductive greensheet.

[Claim 9] A method for producing a lamination ceramic chip inductor according to any one of claims 4, 5 and 6, further comprising the steps of: forming a resist film having a reversed pattern of a desired plated conductive pattern on the conductive base plate, and forming the plated conductive pattern by peeling off the resist film from the base plate after forming a conductive material on an area of the resist film where the base plate is exposed as a method for electroforming.

[Claim 10] A method for producing a lamination ceramic chip inductor according to any one of claims 4, 5 and 6, wherein the base plate is a metal plate treated to be releasable so as to have conductivity.

[Claim 11] A method for producing a lamination ceramic chip inductor according to any one of claims 4, 5 and 6, wherein the conductive base plate is a stainless steel plate.

[Claim 12] A method for producing a lamination ceramic chip inductor according to any one of claims 4, 5 and 6, wherein the plated conductive pattern is formed of Ag, and the Ag plated conductive pattern is formed using an Ag electroplating bath having a pH value of 8.5 or less.

[Claim 13] A method for producing a lamination ceramic chip inductor according to any one of claims 4, 5 and 6, wherein the base plate forming the plated conductive pattern has a surface roughness (Ra) of 0.05 to 1 μm.

[Detailed Description of the Invention]
[0001]

[Field of the Invention]

The present invention relates to a lamination ceramic chip inductor in which a coil-shaped conductive line is formed as a result of sintering a lamination body of a plurality of magnetic sheets or insulation sheets and a plurality of conductive sheets, and a method for producing the same.

[0002]

[Prior Art]

Recently, lamination ceramic chip inductors are widely used in high density mounting circuits, which have been demanded by size reduction of digital devices such as devices for reducing noise.

[0003]

Hereinafter, a method for producing a conventional lamination ceramic chip inductor will be described.

[0004]

A lamination ceramic chip inductor described in, for example, Japanese Laid-Open Utility Model Publication No. 59-145009 is known. On each of magnetic greensheets, a conductive line (conductive paste) of less than one turn is printed in advance. The magnetic greensheets each having the conductive line printed thereon are laminated and attached by pressure. A coil-shaped conductive line is formed by electrically connecting the conductive lines on the top and bottom layers via through-holes formed in the magnetic greensheets. Then, the laminated magnetic greensheets and the coil-shaped conductive lines are entirely sintered.

[0005]

[Problems to be Solved by the Invention]

However, such a conventional lamination ceramic chip inductor requires a larger number of turns of the coil-shaped conductive lines and thus requires a larger number of layers in order to have a high impedance (or inductance).

[0006]

However, an increase in the number of layers to be laminated requires a larger number of lamination steps and thus raises production cost. In addition, such an increase raises the number of points of connection between the greensheets, thus reducing the reliability of connection.

[0007]

In order to solve these problems, a lamination ceramic chip inductor is proposed in Japanese Laid-Open Patent Publication No. 4-93006 as follows. On each of magnetic layers of magnetic sheets, a conductive layer of one or more turns are formed using a thick film printing technology, and the resultant magnetic sheets are laminated. The adjacent conductive layers are electrically connected to each other via a through-hole formed in advance in the magnetic sheets. A lamination ceramic chip inductor produced in this manner has a relatively large impedance even if the number of the laminated sheets is small.

[0008]

However, even such a proposal has the following two disadvantages.

(1) In the case where a small lamination ceramic chip inductor is produced using a thick film conductor printing technology (an outer profile of, for example, 2.0 mm × 1.25 mm or 1.6 mm × 0.8 mm), the number of turns is approximately 1.5 or less for practical use with the production yield and the like considered owing to minute printing. In order to produce a lamination ceramic chip inductor having a larger impedance, the number of the magnetic sheets needs to be increased.

[0009]

(2) In order to increase the number of turns of one thick film printed conductive layer, the width of the thick film conductor needs to be reduced. Since a reduced width of the conductor increases the resistance thereof, the thickness of the printing needs to be increased. However, in order to maintain the printing resolution, the thickness of the conductor needs to be reduced as the width thereof is decreased (for example, when the width of the printed conductor is 75 µm, the thickness of the conductive pattern when being dry is considered to be restricted to approximately 15 µm at the maximum).

[0010]

Accordingly, it is appreciated that the method of simply increasing the number of turns of the thick film printed conductor is not very practical although the effect of reducing the number of the laminated sheets to some extent is recognized.

[0011]

In order to reduce the resistance of the conductor, Japanese Laid-Open Patent Publication No. 3-219605

discloses forming a groove in a greensheet, and filling the groove with a conductive paste to increase the thickness of the thick film conductor. However, it is difficult to mass-produce greensheets grooved in a complicated pattern.

[0012]

Furthermore, Japanese Laid-Open Patent Publication No. 60-176208 also discloses a lamination body having magnetic layers and conductors of approximately a half turn for forming coil alternately laminated, in which the conductors to be formed into a conductive coil are formed by punching a metal foil to reduce the resistance of the conductor. However, it is very difficult to punch out the metal foil with high precision to form a conductor that fits into a microscopic planar area as demanded by the recent size reduction of various devices. In fact, it is impossible to form a complicated coil pattern having one or more turns by punching. Moreover, it is difficult to arrange a plurality of metal foils obtained by punching at a constant pitch on the magnetic sheet with high precision. Furthermore, when the metal foils adjacent to each other with a magnetic sheet interposed therebetween are connected at the ends of the patterns, defective connection can occur when the connection technology is low.

[0013]

As a solution to the above-described problems from a different point view, Japanese Patent Publication No. 64-42809 and Japanese Laid-Open Patent Publication No. 4-314876 disclose a method for producing a lamination ceramic capacitor by transferring a metal thin layer formed on a film onto a ceramic greensheet.

[0014]

In other words, a desired metal layer is obtained by wet plating on a releasable metal thin layer formed on a film by evaporation. When necessary, an extra portion of the metal layer is removed by etching. The resultant pattern is transferred onto a ceramic greensheet.

[0015]

By applying such a transfer method, it is possible to form a coil-shaped conductive line and transfer the conductive line onto a magnetic greensheet.

[0016]

Namely, a lamination ceramic chip inductor with a large impedance can be obtained by etching a relatively thin metal layer (having a thickness of, for example, 10 μm or less) formed on a film to be transferred using a photoresist method and thus obtaining a fine conductive pattern (having a width of, for example, 40 μm and a space between lines of, for example, 40 μm).

[0017]

By the above-described transfer method, it is difficult to obtain a relatively thick metal film to be transferred (having a thickness of, for example, 10 μm or more) with a fine precision in pattern.

[0018]

The reason is that, since the metal layer which is once formed on the entire surface is patterned by removing an unnecessary portion by etching by the transfer method using wet plating, production of a fine conductive pattern becomes more difficult as the thickness of the

metal layer increases.

[0019]

Moreover, since the desired metal pattern is obtained under the etching resist, the etching resist needs to be removed before transferring the metal pattern. When the etching resist is removed, the metal pattern may be removed together with the resist. Such a phenomenon is more likely to occur as the thickness of the metal layer increases. A conceivable reason is that, as the thickness of the metal layer increases, etching requires a longer period of time and thus the thin metal film layer is exposed to the etchant to a higher degree.

[0020]

Accordingly, the objective of reducing the resistance of the conductor cannot be fully achieved even by this transfer method.

[0021]

[Means for Solving the Problems]

In order to solve the above-mentioned problems, a lamination ceramic chip inductor according to the present invention includes a coil-shaped conductive line obtained by laminating a plurality of magnetic bodies or insulation layers with a plurality of conductive layers alternately, and then electrically connecting each of the conductive layers, wherein at least one of the conductive layers is a plated conductive layer formed to have pattern as a result of electroforming.

[0022]

[Function]

By such a structure, since the conductive pattern of a lamination ceramic chip inductor produced according to the present invention is formed by electroforming using a photoresist film or the like, the thickness of the conductive pattern can be sufficient to obtain a sufficiently low resistance, and the width of the conductive pattern can be adjusted with high precision.

[0023]

In contrast to a thick film conductive pattern formed by printing or the like, the conductive pattern formed according to the present invention is shrunk in the thickness direction only slightly by sintering. Thus, the magnetic layer and the conductive layers are not delaminated from each other at all.

[0024]

[Examples]

(Example 1)

Hereinafter, a first example of the present invention will be described with reference to the drawings.

[0025]

Figure 1 is an exploded isometric view showing a structure of a lamination ceramic chip inductor in a first example according to the present invention.

[0026]

In all the figures, only one lamination ceramic chip inductor is illustrated for simplicity. In actual production, a plurality of lamination bodies are formed on one plate and separated after the lamination bodies are completed.

[0027]

In Figure 1, the reference numerals 1, 3 and 6 denote magnetic sheets. The reference numerals 2 and 5 denote coil-shaped plated conductors formed to be transferred on the magnetic sheets 1 and 6, the conductors being formed by electroforming; namely, by forming a resist film having a desirable pattern and then forming a conductive pattern by plating. The reference numeral 4 denotes a through-hole for connecting the coil-shaped plated conductors 2 and 5 to each other.

[0028]

A method for producing the lamination ceramic chip inductor having the above-described structure will be described, hereinafter.

[0029]

First, a method for forming the coil-shaped plated conductors 2 and 5 formed to be transferred by electroforming will be described with reference to Figure 2.

[0030]

As shown in Figure 2, a stainless steel base plate 8 is entirely treated by strike plating with Ag to obtain an Ag release layer 9 having a thickness of approximately 0.1 µm or less as a conductive release layer.

[0031]

The strike plating with Ag can be performed by using an alkaline Ag-CN type plating bath, which is generally used. An exemplary composition of an alkaline Ag-CN type plating bath is shown in Table 1.

[0032]

[Table 1]

Exemplary composition of Ag strike plating bath

| | |
|---|---|
| AgCN | 3.8 to 4.6 g/ℓ |
| KCN | 75 to 90 g/ℓ |
| Liquid temperature | 20 to 30°C |
| Current density | 1.6 to 3.0 A/$dm^2$ |

[0033]

When the Ag plating bath shown in Table 1 is used, an Ag release layer 9 having a thickness of approximately 0.1 μm can be obtained in approximately 5 to 20 seconds.

[0034]

One probable reason that the Ag release layer 9 has releasability is: since an Ag layer is formed by strike plating (high-speed plating) on the stainless steel base plate 8 which has a low level of adherence with Ag, the resultant Ag layer becomes highly strained and thus cannot strongly adhere the stainless steel base plate 8.

[0035]

In order to obtain an optimum level of releasability between the Ag release layer 9 and the stainless steel base plate 8, the surface of the stainless steel base plate 8 is preferably roughened to have a surface roughness (Ra) in the range of approximately 0.05 μm to approximately 1 μm.

[0036]

As a method for roughening the surface, acid treatment, blasting or the like can be used. In the case where the surface roughness (Ra) is approximately 0.05 μm or less, the adherence between the Ag release layer 9 and the stainless steel base plate 8 is insufficient, and thus the Ag release layer 9 is possibly delaminated during the later in the process. In the case where the surface roughness (Ra) is approximately 1 μm or more, the adherence between the Ag release layer 9 and the stainless steel base plate 8 is excessive and thus the Ag release layer 9 may not be satisfactorily transferred onto the magnetic sheet, or the resolution of a plating resist pattern 11 may be lowered.

[0037]

On the other hand, roughening the surface of the stainless steel base plate 8 appropriately has such side effects that the adherence of the plating resist pattern 11 which is formed in the next step is improved and that the Ag release layer 9 is prevented from being released during removal of the plating resist pattern 11.

[0038]

The Ag release layer 9 can also be formed by silver mirror reaction.

Furthermore, the base metal plate can be formed of a material other than stainless steel and processed to have releasability so as to be conductive. Main materials and the respective methods are shown in Table 2.

[0039]

[Table 2]

Exemplary metals usable as base metal plate

| Usable metal | Method for providing releasability |
|---|---|
| Iron-nickel-type metal | Anodizing with NaOH(10%) (forming an excessively thin oxide film) |
| Copper-nickel-type metal | Immersing in potassium bichromate to form a chromate film. |
| Aluminum | Immersing in a zinc substitution liquid to treat with zincate. |
| Copper, brass | Immersing in a 0.5% solution of selenium dioxide |

[0040]

Instead of using a metal base plate, a similar effect can be achieved by using a printed circuit board having a copper foil laminated thereon, or by providing a PET film or the like with conductivity, but a metal plate is more efficient since it is not necessary to provide a metal plate with conductivity.

[0041]

In particular, a stainless steel plate is chemically stable and has satisfactory releasability due to a chrome oxide film existent on a surface thereof, and thus is the easiest to use.

[0042]

After the Ag release layer 9 is formed, a dry

film resist is laminated on the Ag release layer 9 and pre-dried. Then, the dry film resist is exposed to light and thus developed using a photomask used to form a conductor coil having a width of 70 μm and approximately 2.5 turns on each of unit areas having a size of 2.0 × 1.25 mm², thereby forming the plating resist pattern 11 having a thickness T = 55 μm.

[0043]

As the photoresist, various kinds of plating resist (liquid, paste, dry film) can be used. A dry film has a uniform thickness of the resist and thus controls the thickness of the conductive film with relatively high precision, but is preferably used for forming a conductive pattern having a width of approximately 50 μm or more with the sensitivity thereof being considered.

[0044]

In the case of a liquid photoresist, a conductive pattern having a width of several microns can be obtained.

[0045]

In the case of a paste photoresist, which is the photoresist most generally used, a conductive pattern having a width of approximately 40 μm and a thickness of approximately 30 to 40 μm can be obtained.

[0046]

In such a case, for example, a coil-shaped conductive pattern having approximately five turns can be easily formed on a plane of 2.0 × 1.25 mm², and a pattern having approximately three turns can be easily formed on a plane of 1.6 × 0.8 mm².

[0047]

Moreover, depending on the kind of the resist, the resist film can be coated by printing, spin-coating, roll-coating, dipping, lamination or the like.

[0048]

The exposure is performed by an exposure device emitting collimated ultraviolet light rays, and conditions such as exposure time and the light intensity are determined in accordance with the characteristics of the resists.

[0049]

Furthermore, development is performed using a developer suitable for the resist used.

When necessary, exposure to ultraviolet or post-curing is performed after the development to improve the resistance of the resist film against chemicals.

[0050]

Next, after the plating resist pattern 11 is formed, an Ag conductive pattern 10 to be transferred having a necessary thickness t is formed by immersing the plating resist pattern 11 in an Ag electroplating bath. In this example, the Ag conductive pattern 10 is formed so that the thickness t is approximately 50 μm.

[0051]

The most important point in this step is that an alkaline Ag plating bath, which is the type generally used, is not used.

[0052]

Since an alkaline bath acts as a removing liquid to the plating resist film, it destroys the plating resist pattern 11 produced in the previous step.

[0053]

Accordingly, a weak alkaline (neutral) or acid Ag plating bath is required. A weak alkaline (neutral) plating bath shown in Table 3 can be used as a weak alkaline (neutral) plating bath.

[0054]

[Table 3]

Exemplary composition of weak alkaline (neutral) Ag plating bath

| | |
|---|---|
| $KAg(CN)_2$ | 30 g/ℓ |
| KSCN | 330 g/ℓ |
| Potassium citrate | 5 g/ℓ |
| pH | 7.0 to 7.5 |
| Liquid temperature | Room temperature |
| Current density | 2.0 $A/dm^2$ or less |

[0055]

The adjustment of the pH value is performed by ammonia and a citric acid. As a result of various experiments, plating resist of most kinds are removed by having a pH value of more than 8.5.

[0056]

Accordingly, the pH value is preferably set to be 8.5 or less.

Alternatively, an acid plating bath shown in Table 4, or the like can be used.

[0057]

[Table 4]

Exemplary composition of acid Ag plating bath

| | |
|---|---|
| AgCl | 12 g/ℓ |
| $Na_2S_2O_3$ | 36 g/ℓ |
| $NaHSO_3$ | 4.5 g/ℓ |
| $NaSO_4$ | 11 g/ℓ |
| pH | 5.0 to 6.0 |
| Liquid temperature | 20 to 30°C |
| Current density | 1.5 $A/dm^2$ or less |

[0058]

The Ag plating bath shown in Table 4 did not remove the plating resist because of being acid. By adding a surfactant (methylimidazolethiol, furfural, turkey-red oil, or the like), the Ag brilliance and the smoothness of the surface were improved.

[0059]

In this example, a weak alkaline (neutral) bath shown in Table 3 was used. The pH value was set to 7.3.

[0060]

However, the current density for plating is approximately 1A / $dm^2$.

The current density was set to be such a value because when the current density is set to be high in order to perform plating in high speed, strain of the Ag conductive pattern 10 is generated, thus possibly removing the Ag film before the pattern is transferred.

[0061]

In this example, the Ag conductive pattern 10 having a thickness of approximately 50 μm took approximately 260 minutes for plating.

[0062]

By the way, the Ag release layer 9 was formed by strike Ag plating bath (alkaline). Alternatively, the Ag film in the vicinity of the interface with the stainless steel base plate 8 can be provided with releasability by sufficiently straining the Ag film in a weak alkaline (neutral) or acid bath shown above, in which a sufficiently high current density is used for the first several minutes.

[0063]

In this case, the structure becomes as shown in Figure 3, and thus it is unnecessary to form the Ag release layer 9.

[0064]

Next, the plating resist pattern 11 is removed and a structure shown in Figure 4 is obtained.

A removing liquid suitable for a plating resist

film can be used for the plating resist pattern 11; however, usually, the removal can be performed by immersing in an approximately 5% solution of NaOH (liquid temperature of approximately 40°C) for approximately 1 minute.

[0065]

After the plating resist pattern 11 is removed, the Ag release layer 9 having a thickness of approximately 0.1 µm is treated by soft etching (etching time for several seconds) with dilute nitric acid (5%) to leave the isolated coil-shaped Ag conductive pattern 10 on the stainless steel base plate as is shown in Figure 5. The Ag conductive pattern 10 corresponds to the coil-shaped conductive patterns 2 and 5 shown in Figure 1, having approximately 2.5 turns.

[0066]

As the soft etchant for the Ag release layer 9, a sulfuric acid bath of chromic anhydride, a hydrochloric acid bath of an iron chloride, or the like can be also used as well as the dilute nitric acid.

[0067]

Soft etching performed only for several seconds cannot remove the Ag release layer beneath the coil-shaped plated conductive pattern, and thus the Ag conductive pattern is not removed.

[0068]

Hereinafter, a method for forming the magnetic sheets 1, 3 and 6 will be described.

A resin such as a butyral resin, an acrylic resin

or ethylcellulose, and a plasticizer such as dibutylphthalate are dissolved in an alcohol having a low boiling point such as isopropylalcohol or butanol, or in a solvent such as toluene or xylene to obtain a vehicle. The vehicle and a Ni·Zn·Cu type ferrite powder (having an average diameter of approximately 0.5 to 2.0 μm) are kneaded together to form a ferrite paste (slurry). The ferrite paste is formed on a PET film using a doctor blade and then dried at about 80 to 100°C until slight tackiness is left.

[0069]

As for the thickness of each of the magnetic sheet layers 1, 3 and 6; the magnetic sheet layers 1 and 6 are each formed to have a thickness of approximately 0.3 to 0.5 mm, and the magnetic sheet layer 3 is formed to have a thickness of 20 to 100 μm. Then, by punching or the like, the through-hole 4 having sides of approximately 0.15 to 0.3 mm long is formed.

[0070]

Next, the steps for transferring and laminating the coil-shaped plated conductors 2 and 5, with the magnetic sheet layers 1, 3 and 6 will be described.

[0071]

First, the coil-shaped plated conductor 2 already formed is pressed and transferred on the magnetic sheet layer 1 formed on the PET film (if necessary, pressure and heat can be provided). Alternatively, the coil-shaped conductor 2 can be pressed and transferred on a face of the magnetic sheet layer 1 having tackiness (the surface which has been in contact with the PET film) after releasing the

magnetic sheet layer 1 from the PET film.

[0072]

The coil-shaped plated conductor 2 has appropriate releasability from the stainless steel base plate 8 and also has appropriate adhesion with the magnetic sheet layer 1. Thus, the coil-shaped conductor 2 can be easily transferred on the magnetic sheet layer 1 by peeling off the magnetic sheet layer 1 from the stainless steel base plate 8.

[0073]

Moreover, in the case where the strength of the magnetic sheet layer 1 is insufficient, an additional strength can be provided by forming a viscous sheet on the magnetic sheet layer 1.

[0074]

Furthermore, in the same manner, the coil-shaped plated conductor 5 is transferred on the magnetic sheet layer 6.

[0075]

In addition, the two coil-shaped plating conductors 2 and 5 thus obtained are transferred on the magnetic sheet layers 1 and 6, respectively. The magnetic sheet layer 3 is placed between the magnetic sheets 1 and 6 so that the two coil-shaped plated conductors 2 and 5 are laminated to be connected to each other via the through-hole 4. The adherence between the layers is strengthened by adding heat (60 to 120°C) and pressure (20 to 100 kg/cm$^2$).

[0076]

However, electrically connecting the two coil-shaped conductors 2 and 5 with better ohmic electric connection can be obtained by interposing a thick film conductor. Accordingly, a printed thick film conductor 7 is preferably printed and filled in the through-hole 4 of the magnetic sheet layer 3 as is shown in Figure 13.

[0077]

In the above-described process, generally, a plurality of conductive patterns are formed on one sheet in order to obtain a plurality of lamination ceramic chip inductors at the same time to improve the production efficiency. Accordingly, after the resultant sheet is cut into a plurality of bodies, each body is sintered at a temperature of 850 to 950°C for approximately 1 to 2 hours.

[0078]

Lastly, electrodes formed of a silver alloy for connection with an external device are formed on each of two opposed side surfaces of each integral body so as to be electrically connected to the internal coil-shaped plated conductor; and by sintering at approximately 600 to 850°C, outer electrodes 12 shown in Figure 6 are formed. When necessary, the outer electrodes 12 are plated with Ni, solder or the like.

[0079]

By these steps, the lamination ceramic chip inductor having an outer size of 2.0 × 1.25 mm and a thickness of 0.8 mm is obtained. The internal conductor, which includes two coil-shaped plated conductors 2 and 5 each having approximately 2.5 turns, has a coil-shaped

conductive line having 5 turns in total. Accordingly, an impedance of approximately 700 Ω is obtained at a frequency of 100 MHz.

[0080]

The DC resistance could be as small as approximately 0.12 Ω because the thickness of the Ag conductor was approximately 50 μm.

[0081]

Moreover, the lamination ceramic chip inductor according to this example was cut for observation. No specific gap was observed at the interfaces between the Ag conductor and the magnetic layers.

[0082]

The conceivable reason is that the conductor coil produced by electroforming according to the present invention scarcely shrinks from sintering in contrast to a conductor coil formed of thick film conductors, and thus Ag conductor is surrounded by magnetic body with a high density.

[0083]

(Example 2)

Hereinafter, a second example of the present invention will be described with reference to the accompanying drawing.

[0084]

Figure 7 is an exploded isometric view showing a structure of a lamination ceramic chip inductor in the second example of the present invention.

[0085]

In Figure 7, the reference numerals 13 and 18 denote magnetic sheet layers, and the reference numeral 15 denotes a magnetic sheet layer in which a through-hole 16 is formed. The reference numeral 14 denotes a coil-shaped plated conductor formed to be transferred as a result of electroforming, and the reference numeral 17 denotes a thick film conductor printed on the magnetic sheet layer having a through-hole 16. The coil-shaped plated conductor 14 formed to be transferred by electroforming and the printed thick film conductor 17 are connected to each other via the through-hole 16.

[0086]

A method for producing the lamination ceramic chip inductor having the above-described structure will be described.

[0087]

First, the coil-shaped plated conductor 14 to be transferred is produced by electroforming in the same manner as in the first example.

[0088]

In this example, a pattern having a width of approximately 40 μm, a thickness of approximately 35 μm, and approximately 3.5 turns was obtained on an area of $1.6 \times 0.8$ mm$^2$.

[0089]

The resist used is a printable, paste-type resist with high sensitivity.

Hereinafter, a method for forming the magnetic sheet layers 13, 15 and 18 will be described.

[0090]

A resin such as a butyral resin, an acrylic resin or ethylcellulose, and a plasticizer such as dibutylphthalate are dissolved in a solvent having a high boiling point such as terpineol to obtain a vehicle. The vehicle and a Ni·Zn·Cu type ferrite powder (having an average diameter of 0.5 to 2.0 μm) are kneaded together to form a ferrite paste. The ferrite paste is printed on a PET film using a metal mask and then dried at approximately 80 to 100°C (printing and drying are repeated a plurality of times, if necessary) until the thickness of the ferrite paste becomes approximately 0.3 to 0.5 mm. Thus, the magnetic sheet layers 13 and 18 are obtained.

[0091]

Alternatively, each of the magnetic sheet layers 13 and 18 can be obtained by laminating a plurality of magnetic sheet layers printed and dried to have a thickness of approximately 50 to 100 μm.

[0092]

The magnetic sheet layer 15 is produced by forming a pattern having the through-hole 16 on a PET film by screen printing. The thickness of the magnetic sheet 15 is adjusted to be approximately 40 to 100 μm.

[0093]

The coil-shaped plated conductor 14 already formed is pressed and transferred on the magnetic sheet layer 13 formed on the PET film. The condition of pressur-

ing is preferably selected from the range of 20 to 100 kg/cm$^2$, and the condition of heating is preferably selected from the range of 60 to 120°C.

[0094]

The coil-shaped plated conductor 14 has appropriate releasability from the stainless steel base plate and also has appropriate adhesion with the magnetic sheet layer 13. Furthermore, the coil-shaped plated conductor 14 has a relatively small width of 40 μm and thus is slightly buried in the magnetic sheet layer 13. As a result, the coil-shaped plated conductor 14 can be transferred on the magnetic sheet layer 13 easily.

[0095]

Alternatively, the transference can be performed by pressing the coil-shaped plated conductor 14 on a surface of the magnetic sheet layer 13 having plasticizer in the same manner as in the first example.

[0096]

Then, the thick film conductor 17 is printed on the magnetic sheet layer 15 having the through-hole 16.

[0097]

Furthermore, the magnetic sheet 13 having the coil-shaped plated conductor 14 transferred thereon and the magnetic sheet layer 15 having the thick film conductor 17 transferred thereon are laminated so that the coil-shaped plated conductor 14 and the thick film conductor 17 are connected to each other via the through-hole 16. The magnetic sheet layer 18 is laminated on the resultant body, and then the body is heated and pressurized to be formed

into an integral body.

[0098]

In the above-described steps, a plurality of conductive patterns are formed on one sheet, in order to obtain a plurality of lamination ceramic chip inductors at the same time to improve the production efficiency. Therefore, after the resultant sheet is cut into a plurality of bodies, each body is sintered at a temperature of 850 to 950°C for approximately 1 to 2 hours.

[0099]

Lastly, electrodes for connecting with an external device are formed on each of two opposed side surfaces of each body and connected to the conductive coil. Then, the electrodes are sintered at approximately 600 to 850°C, thereby forming outer electrodes 12 shown in Figure 6. When necessary, the outer electrodes 12 are plated with Ni, solder or the like.

[0100]

By these steps, the lamination ceramic chip inductor having an outer size of 1.6 × 0.8 $mm^2$ and a thickness of 0.8 mm is obtained. The internal conductor has a two-layer structure including the coil-shaped plated conductor 14 having approximately 3.5 turns and the thick film conductor 17 having a shape of straight line connected to the coil-shaped plated conductor 14 via the through-hole. Since the lamination ceramic chip inductor has a coil-shaped conductive line having a total of 3.5 turns, an impedance of approximately 300 Ω could be obtained at a frequency of 100 MHz.

[0101]

The DC resistance could be approximately 0.19 Ω because the thickness of the Ag conductor was approximately 35 μm.

[0102]

In this example, only two conductors i.e., a coil-shaped plated conductor 14 to be transferred and a thick film conductor 17 are formed. When necessary, a plurality of coil-shaped plated conductors 14 to be transferred and a plurality of thick film conductors 17 can be connected alternately.

[0103]

Moreover, as described in this example, by combining the thick film conductor and the coil-shaped plated conductor, the connecting reliability is improved than in the case where the coil-shaped plated conductors are directly connected to each other.

[0104]

The conceivable reason for this is that the lamination body is sintered in the state where the adherence between the coil-shaped plated conductor and the thick film conductor is strengthened because the thick film conductor is strained easily during the lamination.

[0105]

(Example 3)

Hereinafter, a third example of the present invention will be described with reference to the accompanying drawing.

[0106]

Figure 8 is an exploded isometric view showing a structure of a lamination ceramic chip inductor in the third example of the present invention.

[0107]

In Figure 8, the reference numerals 19 and 24 denote magnetic sheet layers, and the reference numeral 21 denotes a magnetic sheet layer having a through-hole 22. The reference numerals 20 and 23 denote coil-shaped plated conductors formed to be transferred by electroforming. The reference numeral 25 denotes a printed thick film conductor formed in the magnetic sheet layer 21 so as to fill the through-hole 22. The coil-shaped plated conductors 20 and 23 and the printed thick film conductor 25 are connected to each other via the through-hole 22.

[0108]

A method for producing the lamination ceramic chip inductor having the above-described structure will be described.

[0109]

First, the coil-shaped plated conductors 20 and 23 formed to be transferred are produced by electroforming in the same manner as in the first example.

[0110]

In this example, the coil-shaped plated conductor 20 to be transferred having approximately 3.5 turns and coil-shaped conductor 23 to be transferred having approximately 2.5 turns were obtained on a plane of approximately $1.6 \times 0.8$ mm$^2$, both coil-shaped plated conductors having a

width of approximately 40 μm and a thickness of 35 μm.

[0111]

The used resist is a printable, paste-type resist with high sensitivity.

Hereinafter, a method for forming the magnetic sheet layers 19, 21 and 24 will be described.

[0112]

A resin such as a butyral resin, an acrylic resin or ethylcellulose, and a plasticizer such as dibutylphthalate are dissolved in a solvent having a high boiling point such as terpineol to obtain a vehicle. The vehicle and a Ni·Zn·Cu type ferrite powder (having an average diameter of 0.5 to 2.0 μm) are kneaded together to form a ferrite paste. The ferrite paste is printed on a PET film using a metal mask and then dried at approximately 80 to 100°C until slight tackiness is left. Thus, the magnetic sheets 19 and 24 each having a thickness of approximately 0.3 to 0.5 mm are obtained. The magnetic sheet 21 is produced by forming a pattern having the through-hole 22 on the PET film by screen printing, and the thickness thereof is adjusted to be approximately 40 to 100 μm.

[0113]

Then, the thick film conductor 25 is printed so as to fill the through-hole 22.

Next, the coil-shaped plated conductor 20 to be transferred which is already formed is pressed and transferred onto the magnetic sheet layer 19 formed on the PET

film (if necessary, pressure and heat are provided).

[0114]

Similarly, the coil-shaped plated conductor 23 to be transferred is transferred onto the magnetic sheet layer 24.

[0115]

The coil-shaped plated conductor 23 can be transferred onto the magnetic sheet layer 21 instead of the magnetic sheet layer 24.

[0116]

Furthermore, the magnetic sheet 21 having the through-hole 22 is placed between the magnetic sheet layer 19 having the coil-shaped plated conductor 20 transferred thereon and the magnetic sheet layer 24 having the coil-shaped plated conductor 23 thereon. The coil-shaped plated conductors 20 and 23 to be transferred are connected to each other via the thick film conductor 25 filling the through-hole 22, and the resultant body is laminated, heated and pressurized to be formed into an integral body.

[0117]

In the above-described steps, generally, a plurality of conductive patterns are formed on one sheet in order to obtain a plurality of lamination ceramic chip inductors to improve the production efficiency. Therefore, the resultant sheet is cut into a plurality of bodies, and each body is sintered at a temperature of 850 to 1,000°C for approximately 1 to 2 hours.

[0118]

Lastly, electrodes for connection with an external device are formed on each of two opposed side surfaces of each body to be connected to the internal conductive coil. Then, the body is sintered at approximately 600 to 850°C to form outer electrodes 12 shown in Figure 6. In addition, when necessary, the outer electrodes 12 are plated with Ni, solder or the like.

[0119]

By such steps, the lamination ceramic chip inductor having an outer size of approximately 1.6 × 0.8 $mm^2$ and a thickness of approximately 0.8 mm was obtained. The internal conductor has a two-layer structure including the coil-shaped plated conductor 20 having a width of approximately 40 μm and approximately 3.5 turns and the coil-shaped plated conductor 23 having approximately 2.5 turns. Since the lamination ceramic chip inductor has a coil-shaped conductive line having a total of 6 turns, an impedance of approximately 1,000 Ω could be obtained at a frequency of 100 MHz.

[0120]

The DC resistance could be approximately 0.32 Ω because the thickness of the coil-shaped plated conductor was approximately 35 μm.

[0121]

(Example 4)

Hereinafter, a fourth example of the present invention will be described with reference to the accompanying drawing.

[0122]

Figure 9 is an exploded isometric view showing a structure of a lamination ceramic chip inductor in the fourth example of the present invention.

[0123]

In Figure 9, the reference numerals 26 and 31 denote magnetic sheet layers, the reference numeral 28 denotes a magnetic sheet layer having a through-hole 29, and the reference numerals 27 and 30 denote coil-shaped plated conductors formed to be transferred by electroforming.

[0124]

The coil-shaped plated conductors 27 and 30 formed to be transferred by electroforming are connected to each other via the through-hole 29.

[0125]

The production method of the lamination ceramic chip inductor having the above-described structure is the same as in the first example and thus will be omitted.

[0126]

By this example, a lamination ceramic chip inductor having an outer size of approximately 2.0 × 1.25 $mm^2$ and a thickness of approximately 0.8 mm was obtained. The internal conductor has a two-layer structure including the coil-shaped plated conductor 27 having a width of approximately 40 μm and approximately 5.5 turns and the coil-shaped plated conductor 30 having approximately 2.5 turns connected to the coil-shaped plated conductors 27 via the through-hole 29. Since the lamination ceramic chip inductor has a coil-shaped conductive line having a total

of 8 turns, an impedance of approximately 1,400 Ω would be obtained at a frequency of 100 MHz.

[0127]

The DC resistance could be approximately 0.47 Ω because the thickness of the coil-shaped plated conductor was approximately 35 μm.

[0128]

(Example 5)

Hereinafter, a fifth example of the present invention will be described with reference to the accompanying drawings.

[0129]

A lamination ceramic chip inductor in this example will be described with reference to Figure 7 since it has the same structure as that of the inductor in the second example.

[0130]

In Figure 7, the reference numerals 13 and 18 denote magnetic sheet layers, the reference numeral 15 denotes a magnetic sheet layer having a through-hole 16, the reference numeral 14 denotes a coil-shaped plated conductor formed to be transferred by electroforming, and the reference numeral 17 denotes a thick film conductor printed on the magnetic sheet layer having the through-hole 16. The coil-shaped plated conductor 14 to be transformed formed by electroforming and the printed thick film conductor 17 are connected to each other via the through-hole 16.

[0131]

Hereinafter, a method for producing the lamination ceramic chip inductor having the above-described structure will be described.

[0132]

First, the coil-shaped plated conductor 14 formed to be transferred having a width of approximately 40 μm, a thickness of approximately 35 μm, and approximately 3.5 turns was obtained on a plane of approximately 1.6 × 0.8 $mm^2$ in the same manner as in the second example.

[0133]

Next, a method for forming the magnetic sheet layer 13 will be described with reference to Figure 10.

A resin such as a butyral resin, an acrylic resin or ethylcellulose, and a plasticizer such as dibutylphthalate are dissolved in a solvent having a high boiling point such as terpineol to obtain a vehicle. The vehicle and a Ni·Zn·Cu type ferrite powder (having an average diameter of 0.5 to 2.0 μm) are kneaded together to form a ferrite paste. The ferrite paste is printed on a stainless steel base plate 32 having an Ag conductive pattern 34 formed thereon using a metal mask and then dried at approximately 80 to 100°C (when necessary, printing and drying repeatedly) until the thickness of the ferrite paste becomes approximately 0.3 to 0.5 mm.

[0134]

Then, a thermally releasable sheet 35 is pasted on the magnetic sheet layer 33 (if necessary, pressure and heat can be provided). Then, the Ag conductive pattern 34 and the magnetic sheet layer 33 are peeled off from the

stainless steel base plate 32 together with the thermally releasable sheet 35.

[0135]

In this manner, a greensheet having the coil-shaped plated conductor 14 formed on the magnetic sheet layer 13 is obtained.

[0136]

When necessary, before forming the magnetic sheet layer 33 by printing, an Ag release layer 9 as shown in Figure 2 in the first example can be formed on the stainless steel base plate 32 having the Ag conductive pattern 34 formed thereon.

[0137]

By providing such an Ag release layer, the releasability between the magnetic sheet layer 33 and the stainless steel base plate 32 can be further improved. The Ag release layer can be formed by performing dip-coating of a liquid fluorine coupling agent (perfluorodecyltriethoxysilane or the like) and drying at approximately 200°C. The thickness of the release layer is preferably approximately 0.1 µm.

[0138]

On the other hand, the magnetic sheet layer 15 is formed on the PET film by screen printing so as to have the through-hole 16. The thickness of the sheet is adjusted to be approximately 40 to 100 µm, and the sheet is laminated on the coil-shaped plated conductor 14.

[0139]

As the laminating conditions, the pressure is preferably selected from the range of 20 to 100 kg/cm$^2$, and the heating temperature is preferably selected from the range of 80 to 120°C.

[0140]

In this example, the coil-shaped plated conductor 14 is buried in the magnetic sheet layer 13 and has little ruggedness. Accordingly, the magnetic sheet layer 15 can be easily transferred on the magnetic sheet layer 13.

[0141]

Next, the thick film conductor 17 is printed on the magnetic sheet layer 15 so as to be connected to the coil-shaped plated conductor 14 via the through-hole 16.

[0142]

Then, the magnetic sheet layer 18 is laminated thereon followed by heating and pressurizing to be formed into an integral body. In this case, the magnetic sheet layer 18 can be laminated by printing directly.

[0143]

The rest of the steps (cutting and sintering of the resultant greensheet and formation of electrodes on side surfaces, etc.) are performed in the same manner as in the second example.

[0144]

The electric characteristics of the lamination ceramic chip inductor in this example are the equal to those of the lamination ceramic chip inductor in the second example.

[0145]

(Example 6)

Hereinafter, a sixth example of the present invention will be described with reference to the accompanying drawings.

[0146]

A lamination ceramic chip inductor in this example has same structure as those of the inductors in the second and the fifth examples, and will be described with reference to Figures 7 and 11.

[0147]

In Figure 7, the reference numerals 13 and 18 denote magnetic sheet layers, and the reference numeral 15 denotes a magnetic sheet layer having a through-hole 16. The reference numeral 14 denotes a coil-shaped plated conductor formed to be transferred by electroforming, and the reference numeral 17 denotes a thick film conductor printed on the magnetic sheet layer having the through-hole 16. The electroformed coil-shaped plated conductor 14 to be transferred and the printed thick film conductor 17 are connected to each other via the through-hole 16.

[0148]

In a method for producing a lamination ceramic chip inductor having the above-described structure, the steps for transferring the coil-shaped plated conductor 14 to be transferred on the magnetic sheet layer 13 will be described with reference to Figure 11.

[0149]

In the same manner as in the second example, an

Ag conductive pattern 38 (corresponding to the coil-shaped plated conductor 14 to be transferred) having a width of approximately 40 µm, a thickness of approximately 35 µm, and approximately 3.5 turns was obtained on a stainless steel base plate 36 having a plane of approximately 1.6 × 0.8 $mm^2$. A conductive Ag release layer (strike Ag plated layer) 37 is formed between the Ag plated conductive pattern 38 and the stainless steel base plate 36 (Figure 11(a)).

[0150]

Then, a foam sheet 39 having a thermal releasability from the stainless steel base plate 36 is attached to the Ag conductive pattern 38 by heating and foaming from above (when necessary, additional heat and pressure can be provided) (Figure 11(b)).

[0151]

Since the foam sheet 39 has high adhesion, when the foam sheet 39 is peeled off from the stainless steel base plate 36, the Ag conductive pattern 38 and the Ag release layer 37 are transferred onto the foam sheet 39 (Figure 11(c)).

[0152]

A magnetic sheet layer 40 (having a thickness of 50 µm to 500 µm) formed on a PET film or the like by printing or the like is laminated on the Ag release layer 37 on the Ag conductive pattern 38 transferred on the foam sheet 39. In this case, the lamination is performed so that the surface of the magnetic sheet layer 40 having a plasticity is in contact with the Ag release layer 37, and the lamination is repeated until the total thickness of the

magnetic sheet layer 40 becomes approximately 0.3 to 0.5 mm (Figure 11(d)).

[0153]

Of course, when necessary, appropriate heat and pressure can be provided during the lamination.

Then, the resultant integral body including the magnetic sheet layer 40, the Ag conductive pattern 38, the Ag release layer 37 and the foam sheet 39 is heated at approximately 120°C for 10 minutes so that the foam sheet 39 is foamed to be released. Thus, the magnetic sheet layer 40 (corresponding to the magnetic sheet layer 13 in Figure 7) integrated with the Ag conductive pattern 38 (corresponding to the coil-shaped plated conductor 14 in Figure 7) can be obtained (Figure 11(e)).

[0154]

Next, as shown in Figure 7, a magnetic sheet layer 15 having a through-hole 16 is formed on the coil-shaped plated conductor 14 by laminating or printing. Then, a thick film conductor 17 is laminated or printed on the magnetic sheet layer 15 to be connected to the coil-shaped plated conductor 14 via the through-hole 16.

[0155]

Furthermore, a magnetic sheet layer 18 is laminated thereon followed by heating and pressurizing to form an integral body. In this case, the magnetic sheet layer 18 can be laminated by printing directly.

[0156]

The rest of the steps (cutting and sintering of

the resultant greensheet and formation of electrodes on the side surfaces, etc.) are performed in the same manner as in the second example.

[0157]

The electric characteristics of the lamination ceramic chip inductor produced in this example were equal to those in the second example.

[0158]

(Example 7)

Hereinafter, a seventh example of the present invention will be described with reference to the accompanying drawing.

[0159]

Figure 12 is an exploded isometric view showing a structure of a lamination ceramic chip inductor in the seventh example of the present invention.

[0160]

In Figure 12, the reference numerals 41 and 43 denote magnetic sheet layers, and the reference numeral 42 denotes a wave-shaped plated conductor formed to be transferred by electroforming.

[0161]

The electroformed wave-shaped conductive pattern 42 to be transferred is drawn to both of edges of the chip of the lamination ceramic chip inductor.

[0162]

Since the production method of the lamination

ceramic chip inductor having the above-described structure is the same as that in the first example, and thus will be omitted.

[0163]

In this example, a lamination ceramic chip inductor having an outer size of approximately 2.0 × 1.25 $mm^2$ and a thickness of 0.8 mm was obtained. The internal conductor has a structure including the wave-shaped plated conductor having a width of approximately 50 μm running through the magnetic layers in a longitudinal direction thereof. Accordingly, an impedance of approximately 120 Ω would be obtained at a frequency of 100 MHz.

[0164]

The DC resistance could be approximately 0.08 Ω because the thickness of the wave-shaped plated conductor 42 was approximately 35 μm.

[0165]

In this example, the wave-shaped plated conductors were used, but conductive patterns in a shape of straight line can also be used.

[0166]

In the above seven examples, coil-shaped and wave-shaped plated conductors to be transferred are all formed of Ag. If price, specific resistance or resistance against acid need not be considered, Au, Pt, Pd, Cu, Ni or the like and alloys thereof can be used.

[0167]

Moreover, the lamination bodies are all formed of

a magnetic material containing Ni·Zn·Cu. Needless to say, a lamination ceramic chip inductor having an air-core coil characteristic can be produced using a Ni·Zn or Mn·Zn magnetic material, an insulation material having a low dielectric constant, or the like.

[0168]

(Comparative Example)

Hereinafter, a comparative example will be described with reference to the accompanying drawing.

[0169]

Figure 14 is an isometric view showing a method for producing a lamination ceramic chip inductor in the comparative example.

[0170]

In Figure 14, the reference numerals 101 and 111 denote magnetic sheet layers, and the reference numerals 102, 104, 106, 108 and 110 denote thick film conductive layers for forming coil-shaped plated conductors having approximately a half turn.

[0171]

The reference numerals 103, 105, 107 and 109 denote magnetic sheet layers acting as insulation layers for laminating the thick film conductors having approximately half turn, which are placed and laminated so that only an end part of each of the conductive layers having approximately a half turn is exposed.

[0172]

A method for producing the lamination ceramic

chip inductor having the above-described structure will be described.

[0173]

First, as shown in Figure 14(a), a ferrite paste is printed in a rectangle to obtain the sheet 101. Then, a conductive line 102 is formed by printing a conductive paste on the sheet 101 for approximately a half turn (Figure 14(b)).

[0174]

Furthermore, the sheet 103 is formed by printing the ferrite paste to hide a part of the conductive line 102 (Figure 14(c)).

[0175]

Then, the thick film conductive layer 104 having approximately a half turn is formed by printing an Ag conductive paste to be connected to the end of the conductive line 102 (Figure 14(d)).

[0176]

Similarly, a lamination ceramic body having a coil-shaped conductive line of approximately 2.5 turns is obtained by laminating by printing and sintering at a high temperature as is shown in Figures 14(e) through (k).

[0177]

In this comparative example, the conductive pattern having a width of approximately 150 μm and a thickness of approximately 12 μm after being dried is formed on a plane of approximately 1.6 × 0.8 mm.

[0178]

Since the internal conductor has the conductive coil having 2.5 turns, an impedance of approximately 150 Ω could be obtained at a frequency of 100 MHz.

[0179]

The DC resistance was approximately 0.16 Ω because the thickness of the conductive coil after being sintered was approximately 8 μm.

[0180]

In this comparative example, the conductive coil has only 2.5 turns although the inductor includes eleven layers. Accordingly, the impedance is small in consideration of the number of the layers, and the resistance of the conductor is large for the impedance.

[0181]

Moreover, the production steps are complicated, and the connection reliability between the layers is poor.

Although the resistance of the conductor can be reduced by forming each of the thick film conductive layers by transferring the electroformed plated conductive patterns thereon in this example, effects such as reduction in the number of the layers and increase in impedance cannot be expected.

[0182]

[Effect of the Invention]

As has been described so far, according to the lamination ceramic chip inductor and the method for producing the same according to the present invention, a

coil-shaped conductive line is formed by electroforming (plating). Therefore, the width of the conductive patterns can be adjusted with high precision in accordance with the resolution of the photoresist for example, to the extent of several microns. Accordingly, a coil-shaped conductive line having a larger number of turns can be obtained in an area of a microscopic chip component than a conductor formed by printing.

[0183]

Thus, a higher impedance can be obtained although the number of layers is small.

The thickness of the conductive film can be controlled to be in the range from submicrons to several tens of microns by using an appropriate thickness of photoresist or appropriate plating conditions. The thickness of the conductive patterns can be even several millimeters with appropriate conditions. Accordingly, the resistance of the conductor can be easily controlled and thus can be reduced by increasing the thickness of the film despite the fine patterns thereof.

[0184]

In contrast to the case of forming a coil pattern only by thick film conductors, films having a high density can be obtained even before sintering. Thus, reduction of the thickness of the conductors after sintering is insignificant, and the magnetic layers and the conductive layers are scarcely delaminated from each other.

[0185]

Furthermore, the reliability of the characteris-

tics of the product is improved by the precise pattern of the conductor and the high density of the conductor.

[0186]

As described so far, a lamination ceramic chip inductor and a method for producing the same according to the present invention has an excellent effect of realizing a smaller number of layers, a higher impedance, and a lower resistance at the same time.

[Brief Description of the Drawings]

[Figure 1]

An exploded isometric view showing a structure of a lamination ceramic chip inductor in a first example according to the present invention.

[Figure 2]

A descriptive view showing the steps for producing the lamination ceramic chip inductor in the first example according to the present invention.

[Figure 3]

A descriptive view showing the steps for producing the lamination ceramic chip inductor in an example according to the present invention.

[Figure 4]

A descriptive view showing the steps for producing the lamination ceramic chip inductor in an example according to the present invention.

[Figure 5]

A descriptive view showing the steps for produc-

ing the lamination ceramic chip inductor in an example according to the present invention.

[Figure 6]

An isometric view showing the exterior of the lamination ceramic chip inductor in each example according to the present invention.

[Figure 7]

An exploded isometric view showing the lamination ceramic chip inductors in second, fifth and sixth examples according to the present invention.

[Figure 8]

An exploded isometric view showing a structure of a lamination ceramic chip inductor in a third example according to the present invention.

[Figure 9]

An exploded isometric view showing a structure of the lamination ceramic chip inductor in the fourth example according to the present invention.

[Figure 10]

A descriptive view showing the step for producing the lamination ceramic chip inductor in the fifth example according to the present invention.

[Figure 11]

Descriptive views showing the steps for producing the lamination ceramic chip inductor in the sixth example according to the present invention.

[Figure 12]

An exploded isometric view showing a structure of the lamination ceramic chip inductor in the seventh example according to the present invention.

[Figure 13]

A partial isometric view illustrating a modification of the lamination ceramic chip inductor in the first example according to the present invention.

[Figure 14]

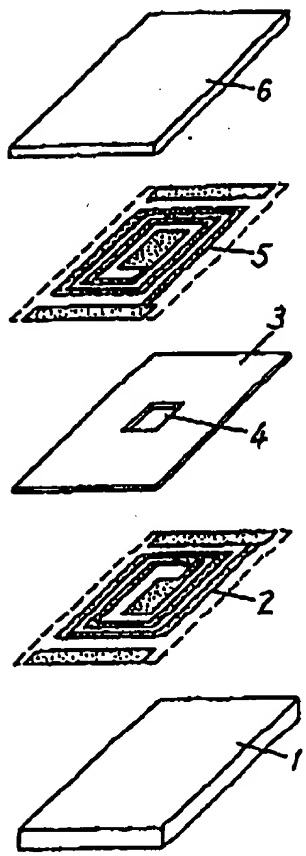
Descriptive views showing the steps for producing the lamination ceramic chip inductor in the comparative example.

[Description of the Reference Numerals]

1, 3, 6, 13, 15, 16, 18, 19, 21, 24, 26, 28, 31, 33, 40, 41, 43 Magnetic sheet layer
2, 5, 14, 20, 23, 27, 30 Coil-shaped plated conductor
4, 16 Through-hole
8, 32, 36 Stainless steel base plate
9, 37 Ag release layer
10, 34, 38 Ag conductive pattern
11 Plated resist pattern
12 Outer electrode
17, 25 Thick film conductor
39 Foam sheet
42 Wave-shaped plated conductor

[Name of the Document] DRAWINGS

[Fig. 1]

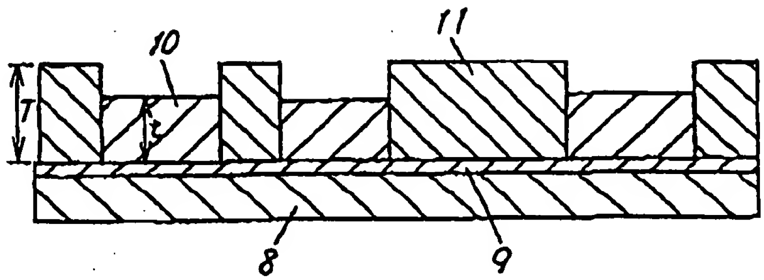



1, 3, 6 Magnetic sheet layer

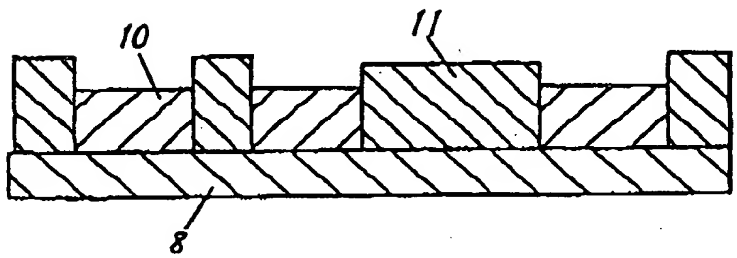
2, 5 Coil-shaped plated conductor

4 Through-hole

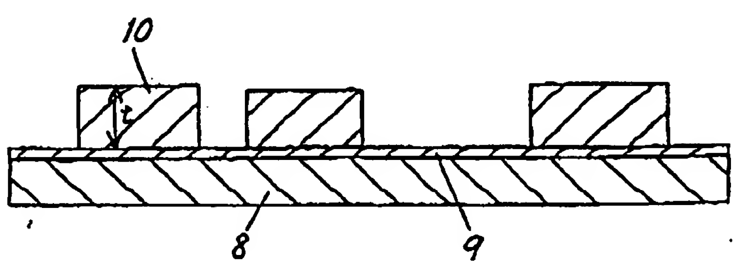
[Fig. 2]



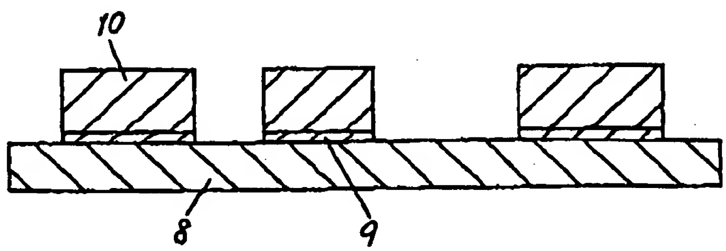

[Fig. 3]




[Fig. 4]

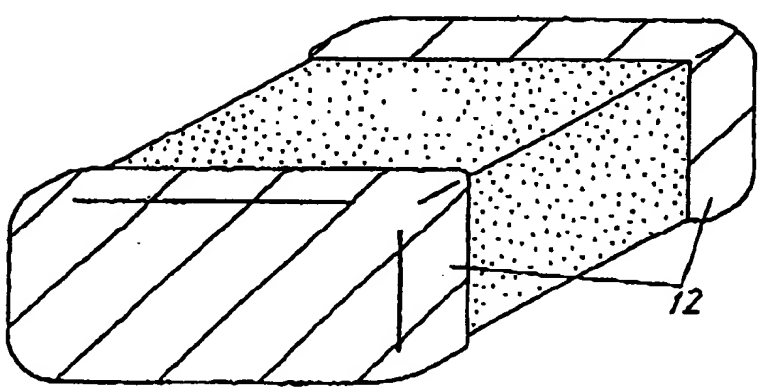


[Fig. 5]

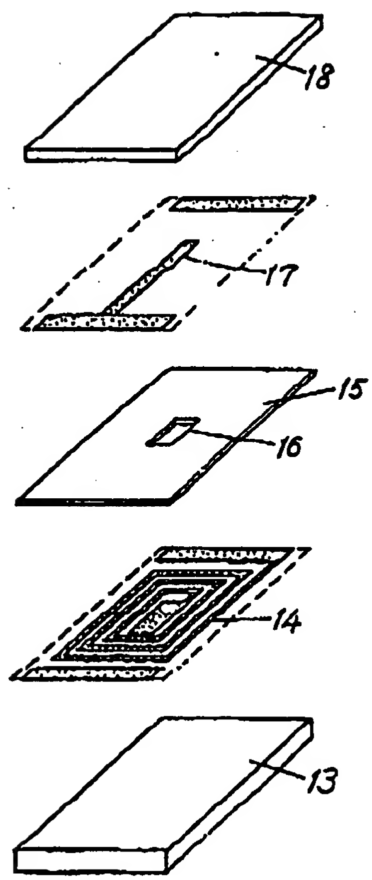



[Fig. 6]

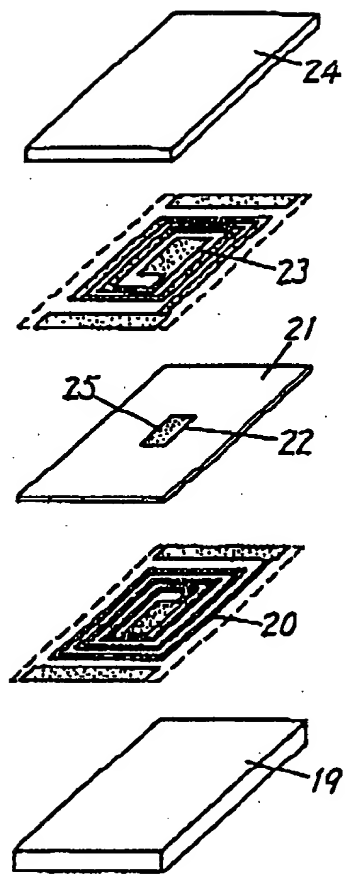
12 Outer electrode



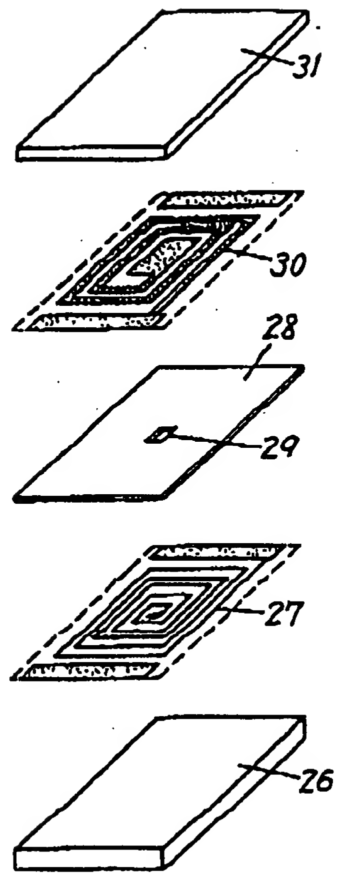
[Fig. 7]



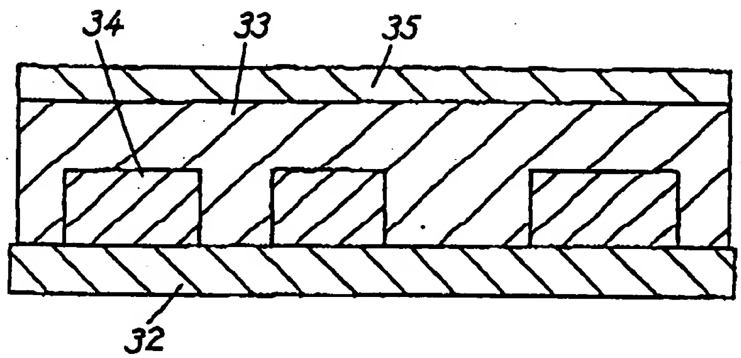
[Fig. 8]



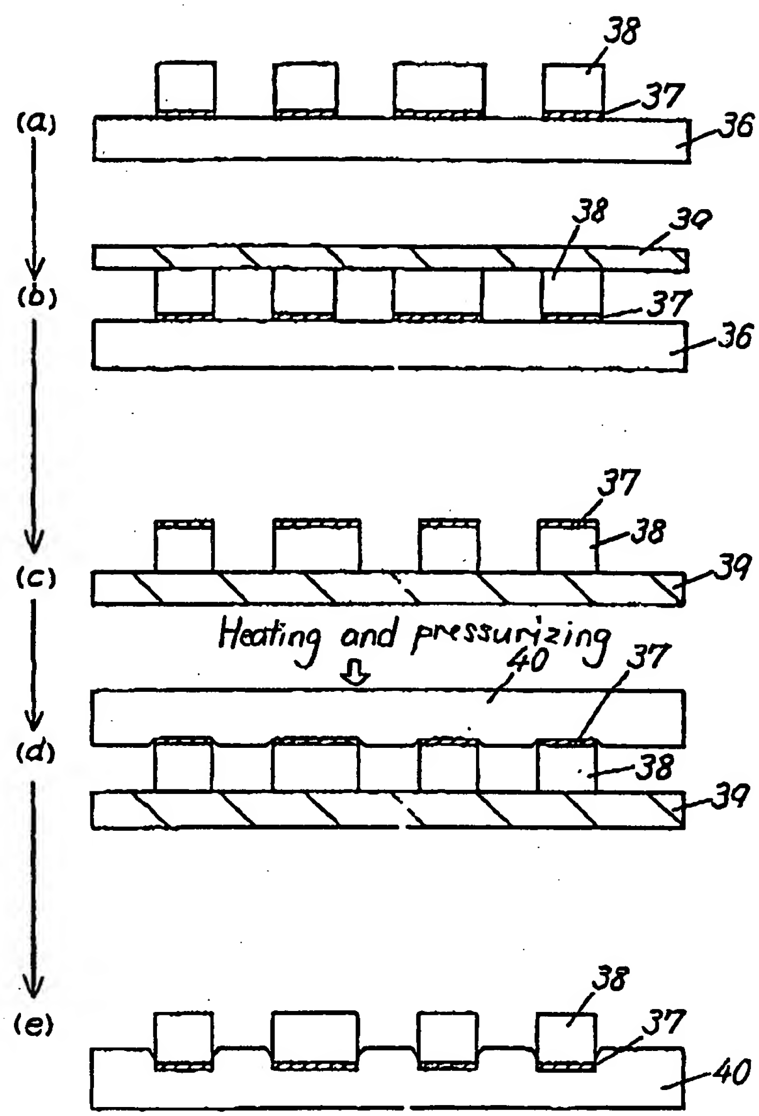
[Fig. 9]



[Fig. 10]



[Fig. 11]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(b)
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(c)
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Heating and pressurizing
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(d)
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(e)
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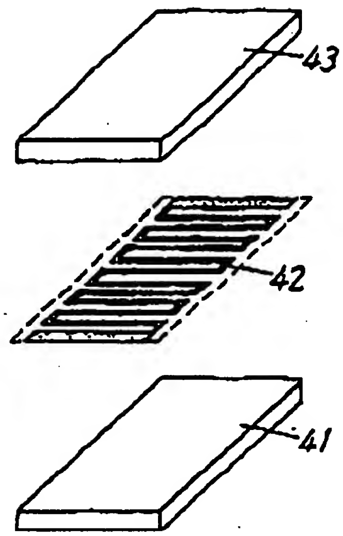
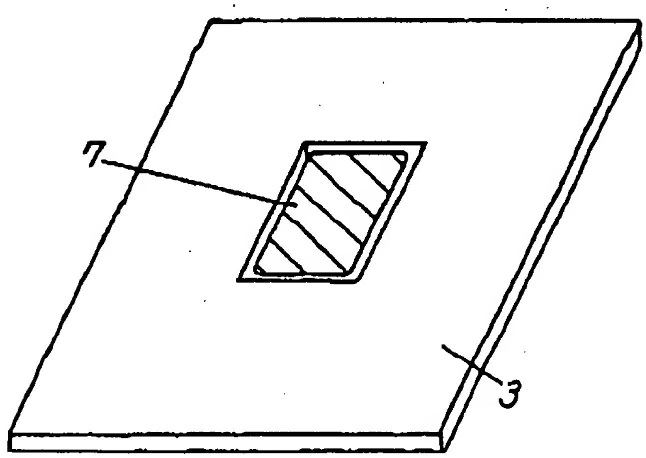
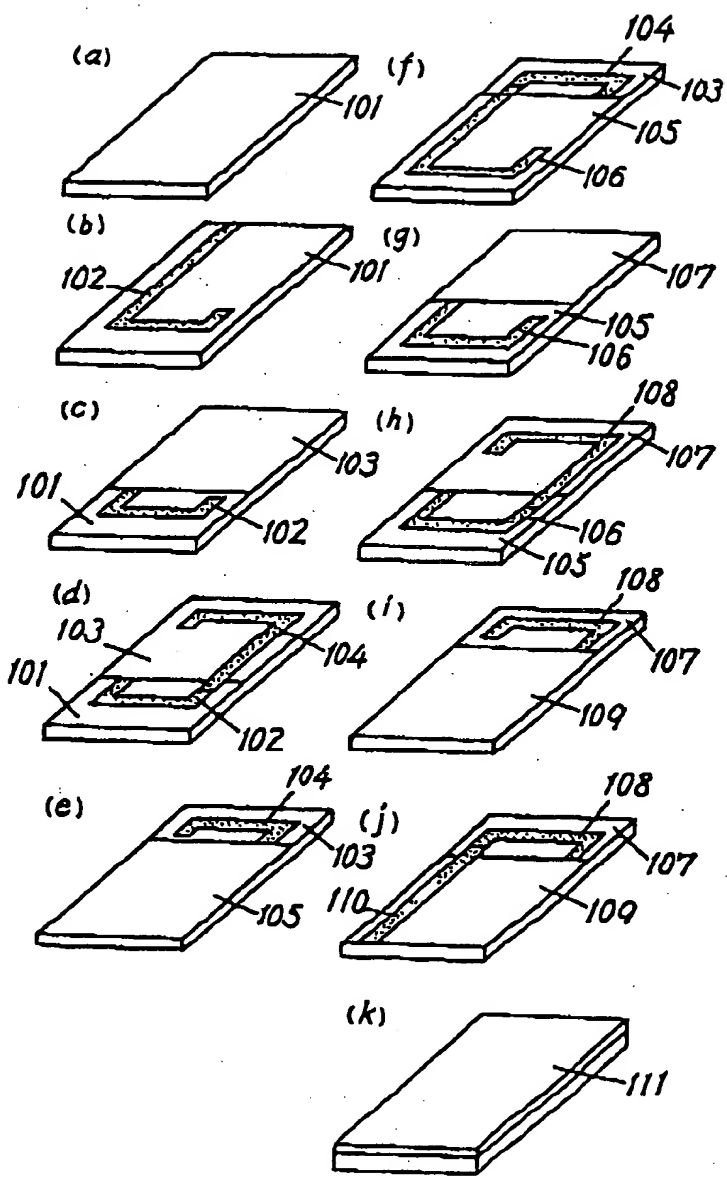
[Fig. 12]




[Fig. 13]



[Fig. 14]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(k)
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[Name of the Document] ABSTRACT

[Abstract]

[Objective] Have an objective of increasing the impedance as well as reducing the resistance of the conductor, and thus improving the reliability and reducing the production cost by reducing the number of layers of a lamination ceramic chip inductor which is widely used in high density mounting circuits which have been demanded by size reduction of digital devices such as devices for reducing noise.

[Structure] By transferring electroformed coil-shaped plated conductors 2 and 5 onto magnetic sheet layers 1 and 6 respectively, and connecting the coil-shaped plated conductors 2 and 5 to each other via a through-hole 4 formed in a magnetic sheet layer 3, reduction in the number of layers, increase in the impedance, and reduction in the resistance of the conductor can be realized at the same time.

[Selected Figure] Figure 1